BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings. In the drawings, related figures have the same number but different alphabetic suffixes.

[0032] **FIG. 1** is a schematic exploded perspective representation of a portion of one embodiment of the invention, showing parts which comprise a haptel moving assembly.

[0033] **FIG. 2** is a schematic exploded perspective representation of a portion of one embodiment of the invention, showing a haptel moving assembly and constraint pins.

[0034] **FIG. 3** is a schematic exploded perspective representation of a portion of one embodiment of the invention, showing parts which comprise a haptel stationary assembly.

[0035] **FIG. 4** is a schematic exploded perspective representation of a portion of one embodiment of the invention, showing a haptel stationary assembly mounted to a support plate.

[0036] **FIG. 5A** is a schematic exploded perspective representation of a portion of one embodiment of the invention, showing the parts and assemblies which comprise a haptel.

[0037] **FIG. 5B** is a schematic perspective representation of a portion of one embodiment of the invention, showing a haptel.

[0038] **FIG. 6A** is a schematic exploded perspective representation of one embodiment of the invention, showing parts and assemblies which comprise a haptel grid with a flexible overlay and a hand rest.

[0039] **FIG. 6B** is a schematic perspective representation of a portion of one embodiment of the invention, showing a haptel grid with a flexible overlay and a hand rest.

[0040] **FIG. 7** is a schematic of a circuit for measuring haptel surface position.

[0041] **FIG. 8** is a schematic of a circuit for driving a haptel actuator.

[0042] **FIG. 9** is a block diagram showing the elements of one embodiment of the invention.

[0043] **FIG. 10** is a flow chart representation of a method for controlling the apparatus.

[0044] The use of the same reference symbols in different drawings indicates similar or identical items.

DETAILED DESCRIPTION OF THE INVENTION

[0045] The following is intended to provide a detailed description of an example of the invention and should not be taken to be limiting of the invention itself. Rather, any number of variations may fall within the scope of the invention which is defined in the claims following the description. In addition, the following detailed description has been divided into sections, subsections, and so on, to highlight the various subsystems of the invention described herein; however, those skilled in the art will appreciate that such sections are merely for illustrative focus, and that the invention herein disclosed typically draws its support from multiple sections. Consequently, it is to be understood that the division of the detailed description into separate sections is merely done as an aid to understanding and is in no way intended to be limiting.

Haptel Description

[0046] **FIG. 1** illustrates various aspects of one embodiment of a haptel according to the present invention and exemplified by a haptel **500**. Haptel **500** includes, primarily, two assemblies: a moving assembly **100** and stationary assembly **300**. **FIG. 1** illustrates an exploded perspective view of the parts of moving assembly **100**.

[0047] An XY sensor **116** is attached to the top of a surface **102**, which is in turn coupled to a coil holder **104**. Edges of XY sensor **116** are preferably folded around surface **102** and fixed into place by glue, for example. An XY cable **118** is provided to couple XY sensor **116** to an XY interface (not shown), to be described later. XY sensor **116** may be implemented using, for example, a four wire resistive film touch sensor. An upper bearing **106** and a lower bearing **110** preferably fit closely around coil holder **104** and are held in by glue, for example. Upper bearing **106** is rotationally aligned with coil holder **104** such that bearing pin holes **106***a* are aligned with coil pin holes **104***a*, constituting constraint pin holes **100***a*. Magnet wire **108** is wound around coil holder **104** between upper bearing **106** and lower bearing **110**. Magnet wire ends **108***a* are routed through a lower wire hole **104***b*, through the interior of coil holder **104**, and through an upper wire hole **104***c*. Magnet wire ends **108***a* are electrically coupled to a coil cable **114**. Magnet wire ends **108***a* are mechanically but not electrically coupled (e.g., non-consecutively glued) to the top of coil holder **104** for purposes of strain relief.

[0048] Surface **102** and a coil holder **104** may be made, for example, of a non-ferromagnetic material with good heat conductivity (e.g., 6110-T6 aluminum alloy). Preferably, the interior sides of coil holder **104** are painted black and the interior top is painted white. Upper bearing **106** and lower bearing **110** are made of a low friction material, such as polytetraflouroethylene (PTFE). Coil cable **114** and XY cable **118** may be, for example, high-flexibility multi-conductor shielded cables, with jacket and shield removed from the flexing portion. Magnet wire **108** may be, for example, standard insulated magnet wire.

[0049] **FIG. 2** illustrates an exploded perspective view of moving assembly **100** and constraint pins **200**. This figure shows how constraint pins **200** fit into constraint pin holes **100***a*. Constraint pins **200** may be, for example, metal cylinders with a smooth surface, such as spring steel wire.

[0050] **FIG. 3** illustrates an exploded perspective view of stationary assembly **300**. In the embodiment shown in **FIG. 3, a** flux disk **306** is attached to a magnet **304**, which in turn is attached to a base **302**. A proximity sensor **308** is electrically coupled to a position cable **310**, which passes through flux disk hole **306***a*, magnet hole **304***a* and base cable hole **302***a*. Position cable **310** couples proximity sensor **308** to a position circuit (not shown), to be described later. Position cable **310** is preferably a shielded four conductor cable. Preferably, the bottom of proximity sensor **308** is flush with the top of flux disk **306** and secured (e.g., glued into place). A spring **312** is affixed to flux disk **306** surrounding proximity sensor **308**. A lower base bearing **314** preferably fits closely inside a midsection **316**, and is